Recitation W3

Jihan Kim

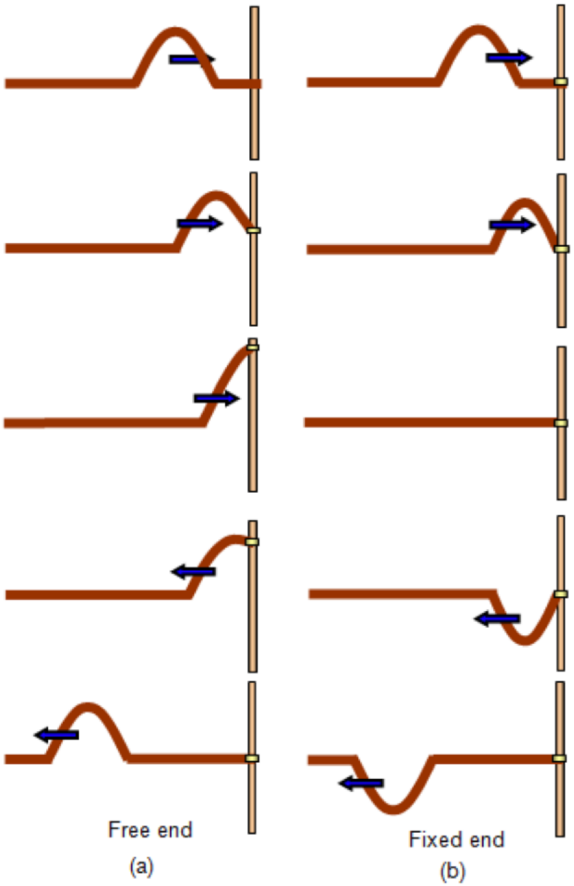
Announcement

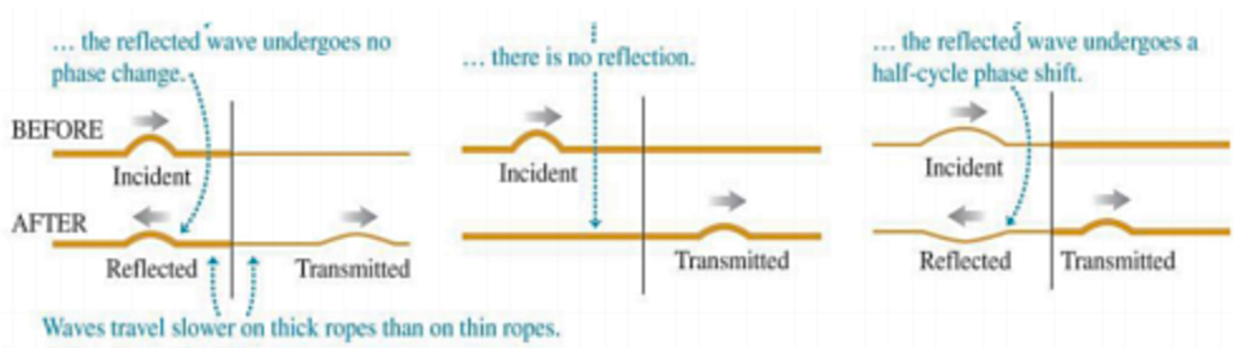
- Midterm exam 1
  - April 24th (Wednesday) 7:00 – 8:20 p.m.
- Prep session for the midterm
  - April 23rd (Tuesday)
  - Jihan: T 10 a.m., 2 p.m.
  - Feel free to go other sessions
- Midterm exam review
  - April 25th (Thursday)

Topic

- Thin film interference
- Snell’s law
- Ray optics

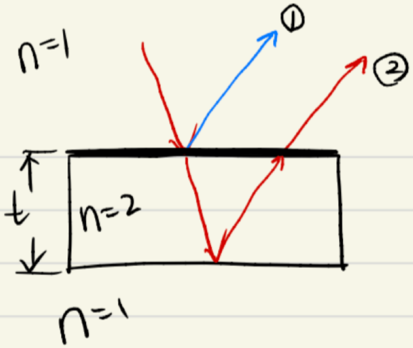
Thin film

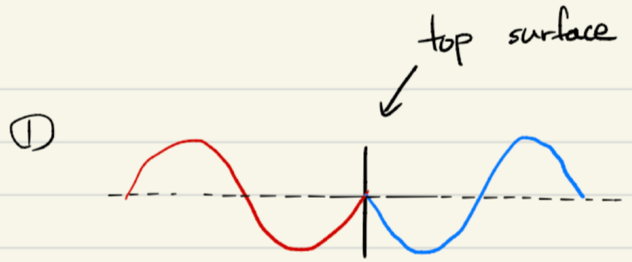


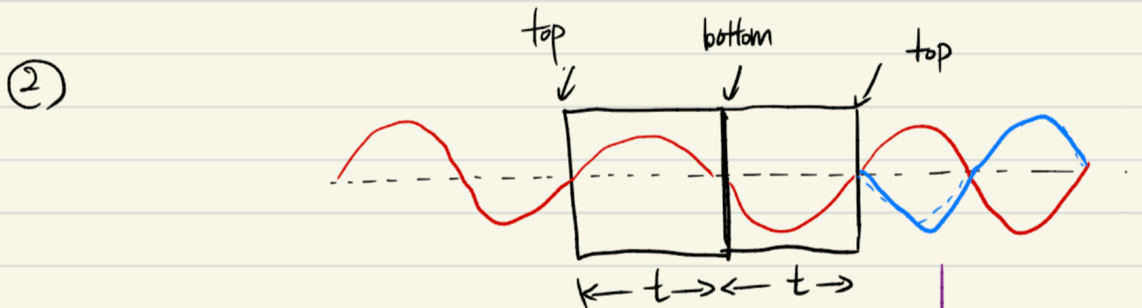


- $n = \frac{c}{v} = \frac{\lambda_{vacuum}}{\lambda_{film}}$
- f (frequency) = const.

- n (high) $\rightarrow$ n (low) : $\phi = 0$
- n (low) $\rightarrow$ n (high) : $\phi = \pi$

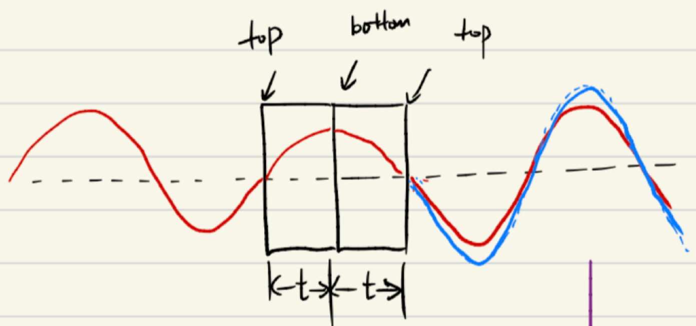






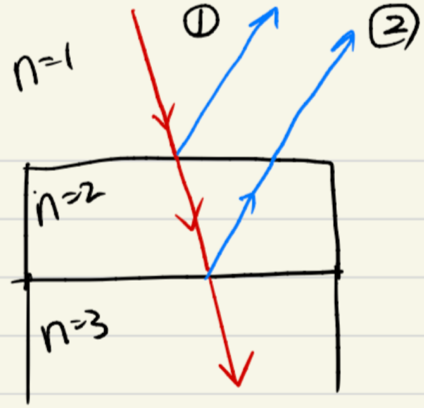
$$2t = m\lambda \quad (m = 1, 2, 3, \cdots)$$

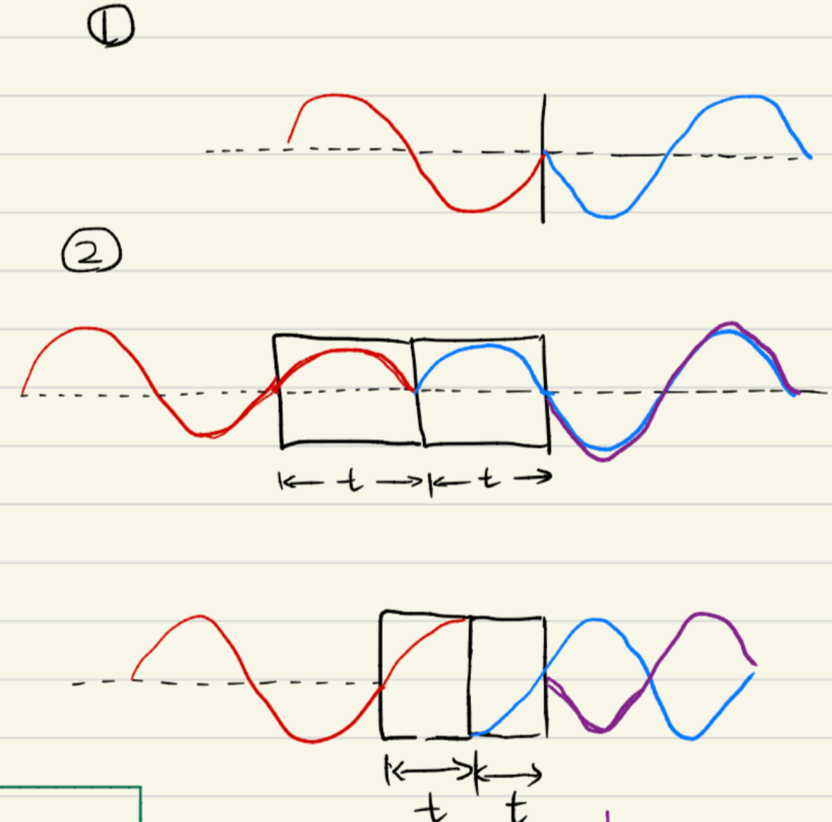
⇒ Destructive



$$2t = \left(m + \frac{1}{2}\right)\lambda \quad (m = 1, 2, 3, \cdots)$$

⇒ constructive





Constructive

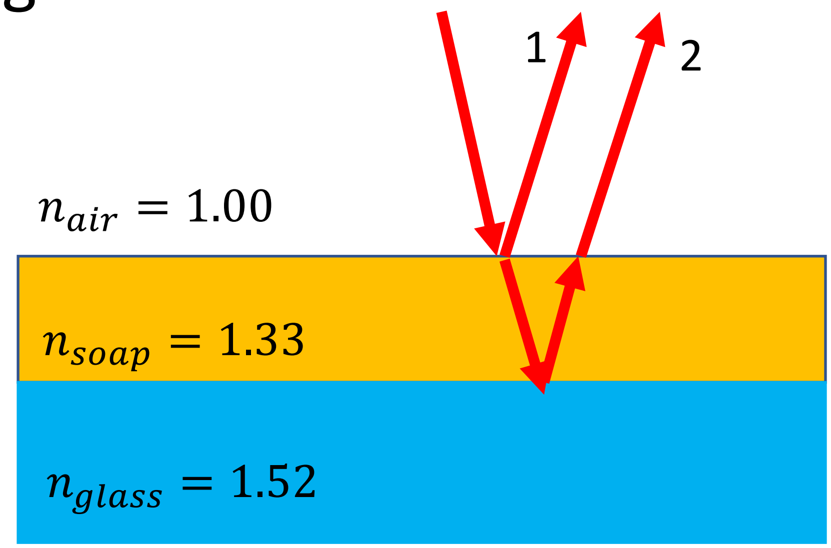
$$2t = m\lambda \quad (m=1, 2, 3, \cdots)$$

Destructive

$$2t = \left(m+\frac{1}{2}\right)\lambda$$

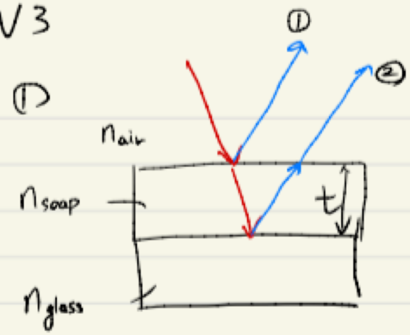
$(m = 0, 1, 2, 3 \ldots)$

- A soap film (n=1.33) is 375 nm thick and coats a flat piece of glass (n=1.52). Thus, air is on one side of the film and glass is on the other side. Sunlight, whose wavelengths (in vacuum) extend from 380 to 750 nm, travels through the air and strikes the film nearly perpendicularly. For which wavelength(s) in this range does constructive interference cause the film to look bright in reflected light?



W3

①



$\Rightarrow$ ① & ② both have phase shift by π

$n_{low} \rightarrow n_{high}$

To have constructive interference

$$\Rightarrow 2t = m\lambda_{soap} \qquad (m = 1, 2, 3, \cdots)$$

$$\lambda_{soap} = \frac{\lambda_{vac}}{n_{soap}} \leftarrow \left(n_{soap} = \frac{V_{vac}}{V_{soap}} = \frac{\lambda_{vac}}{\lambda_{soap}} \right)$$

$$\Rightarrow 2t = m\frac{\lambda_{vac}}{n_{soap}}$$

$$\lambda_{vac} = \frac{2t n_{soap}}{m} = \frac{2(375 \times 10^{-9} m)(1.33)}{m}$$

$m = 1 \rightarrow \lambda_{vac} = 998\,nm$

$m = 2 \rightarrow \lambda_{vac} = 499\,nm$

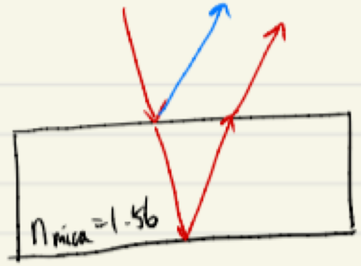
$m = 3 \rightarrow \lambda_{vac} = 333\,nm$

$m = 4 \rightarrow \lambda_{vac} = 249\,nm$

$380\,nm \leq \lambda_{visible} \leq 750\,nm$

$\lambda = 499\,nm$

2. Muscovite (n = 1.56), or better known as mica, is a phyllosilicate mineral of aluminum and potassium. New industrial uses include being an insulator, usually for small electrical components. Fabrication of devices with mica often require high precision in the determination of the mica thickness. If a mica sheet is suspended in air and reflected light shows gaps in the visible spectrum at 450, 525, and 630 nm, what is the thickness of the mica sheet?



gap → destructive at $\lambda_{vac} = 450$, 525, 630 nm

$$2t = m\lambda_{mica} \longleftarrow \lambda_{mica} = \frac{\lambda_{vac}}{n_{mica}}$$

$$2t = m \cdot \frac{\lambda_{vac}}{n_{mica}}$$

$$t = \frac{m \cdot \lambda_{vac}}{2n_{mica}}$$

	m = 4	m = 5	m = 6	m = 7
λ_{vac} = 450 nm	576.9	721.2	865.4	1009.6
525 nm	673.1	841.3	1009.6	1177.9
630 nm	807.7	1009.6	1211.5	1413.5

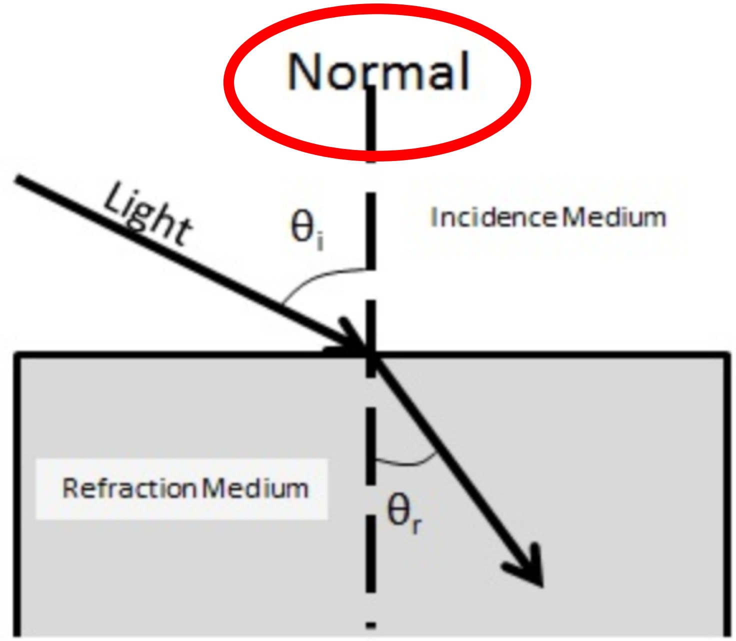
↙ common thickness

∴ $t = 1.01\ \mu m$

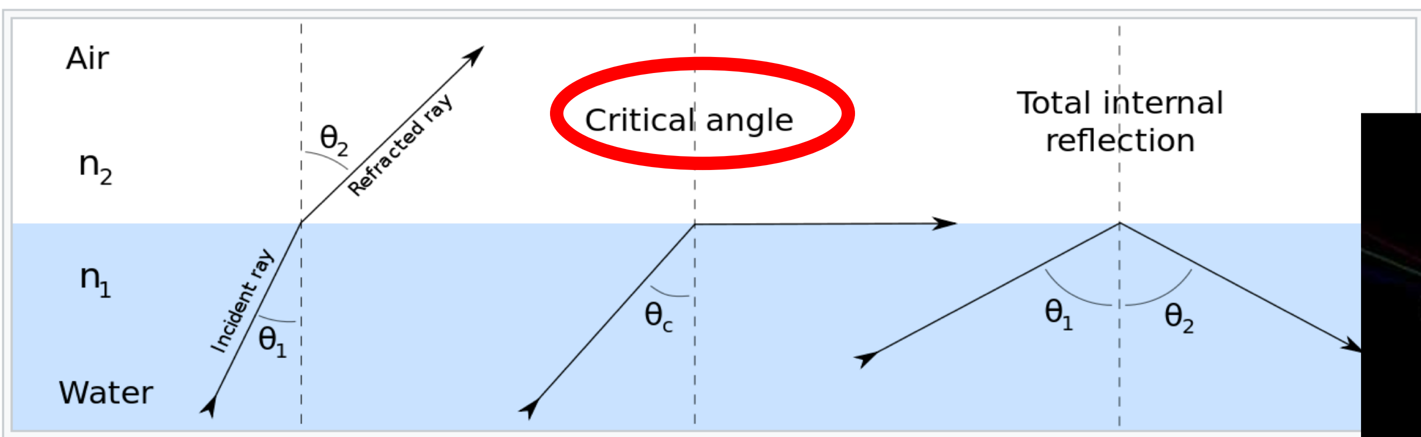
Snell's law

$$n_i \ * \ \sin\theta_i = n_r \ * \ \sin\theta_r$$

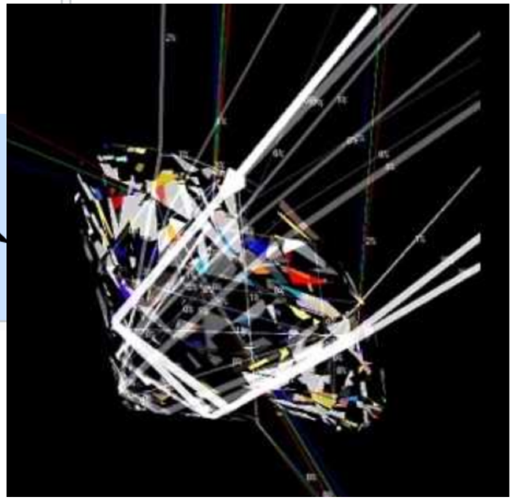
n_i = Index of Refraction of Incidence Medium
n_r = Index of Refraction of Refraction Medium
θ_i = Angle of Incidence
θ_r = Angle of Refraction



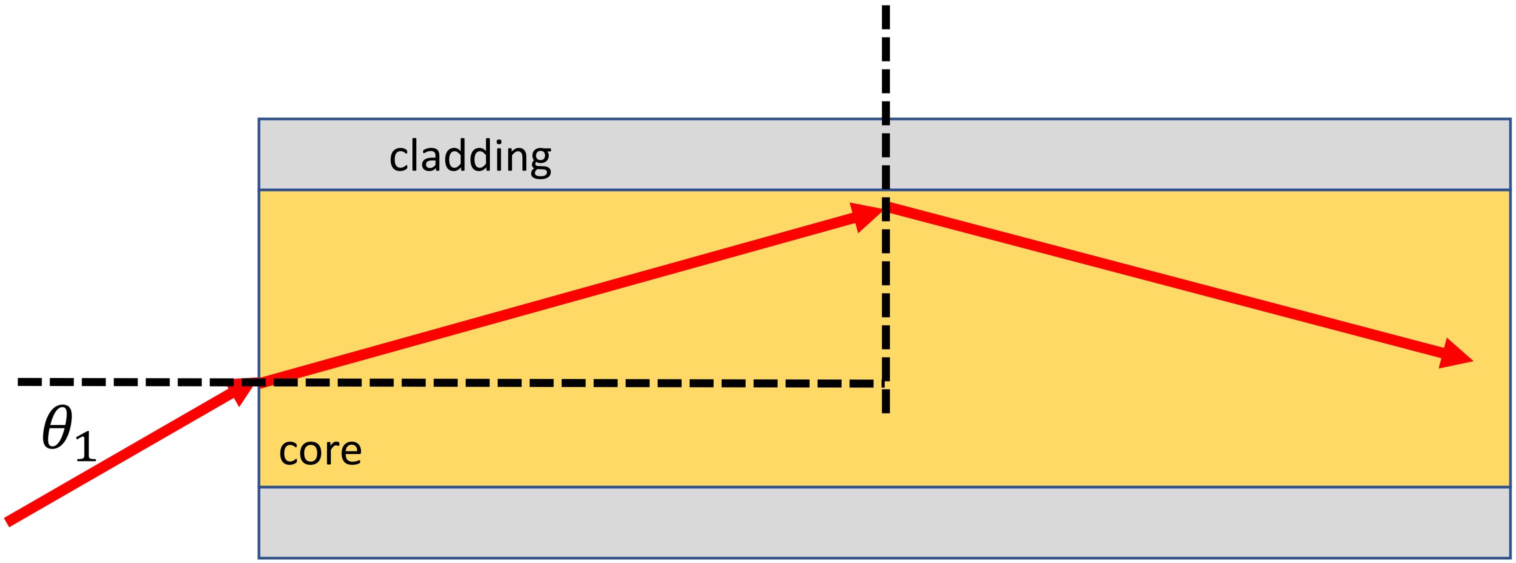
- Total internal reflection

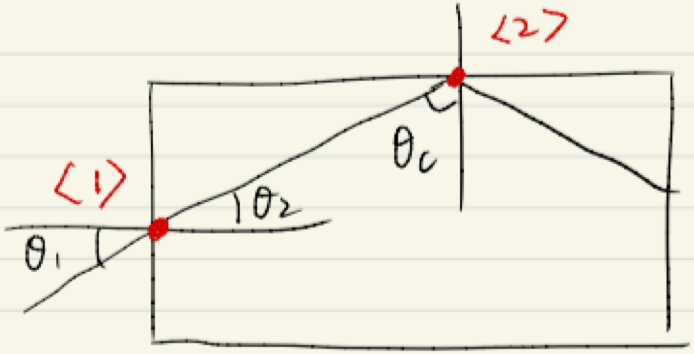


$$\theta_c = \sin\left(\frac{n_{low}}{n_{high}}\right)$$



- An optical fiber that consists of a core made of flint glass ($n_{flint} = 1.667$) surrounded by a cladding made of crown glass ($n_{crown} = 1.523$). A ray of light in air enters the fiber at an angle θ_1 with respect to the normal. What is θ_1 if this light also strikes the core– cladding interface at an angle that just barely exceeds the critical angle?





<1>

$$n_{air}\sin\theta_1 = n_{flint}\sin\theta_2$$

$$\theta_1 = \sin^{-1}\left(\frac{n_{fint}}{n_{air}}\sin\theta_2\right)$$

<2>

$$n_{flint}\sin\theta_c = n_{crown}\sin 90^\circ$$

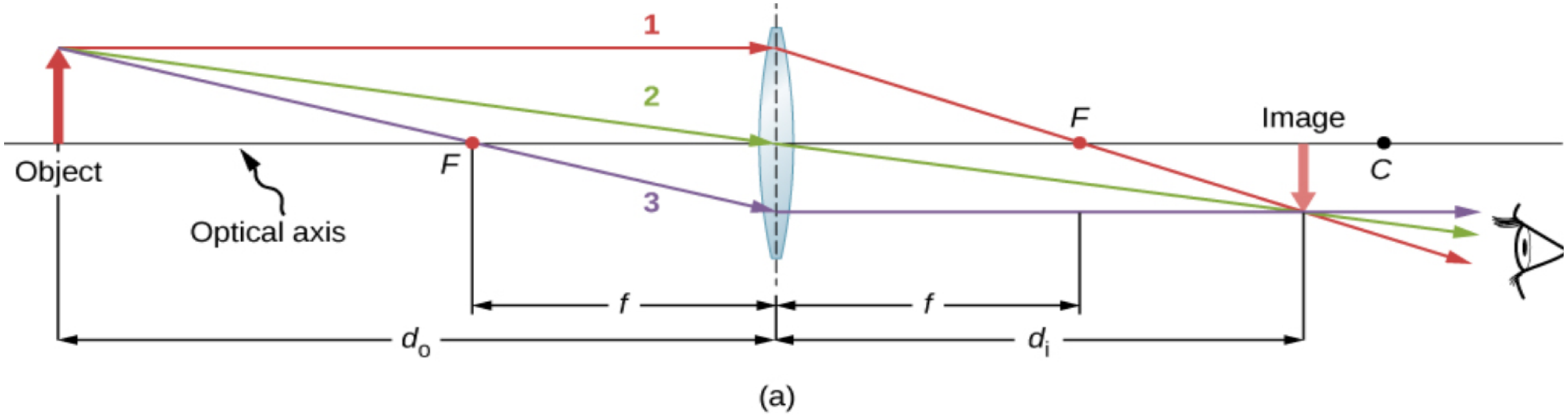
$$\theta_c = \sin^{-1}\left(\frac{n_{crown}}{n_{flint}}\right)$$

$$= \sin^{-1}\left(\frac{1.523}{1.667}\right) = 66.01^\circ$$

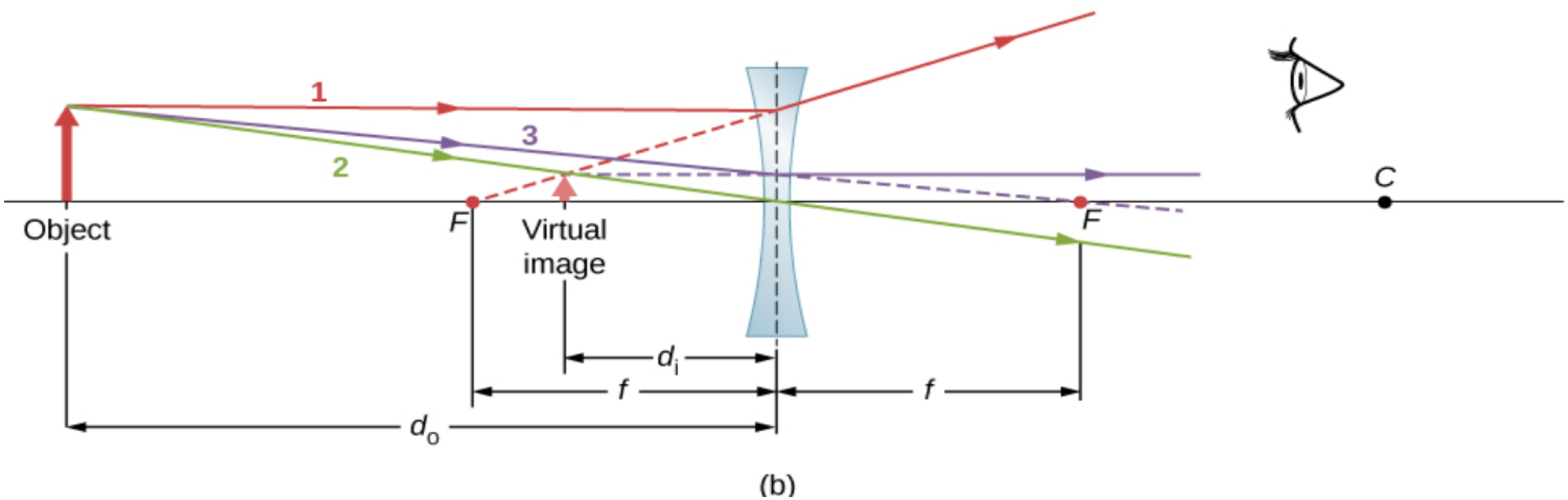
$$\theta_2 = 90^\circ - \theta_c = 23.99^\circ$$

$$\theta_1 = \sin^{-1}\left(\frac{1.667}{1}\cdot\sin(23.99^\circ)\right) = 42.67^\circ$$

Ray optics



1
2
3
Object
Optical axis
F
F
Image
C
f
f
d o
d i
(a)



1
3
2
Object
F
Virtual image
F
C
d i
f
f
d o
(b)

- Lens equation

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

- Magnification

$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$